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Risk, knowledge and preventive measures of smallholder dairy farmers in northern Malawi with regard to zoonotic brucellosis and bovine tuberculosis

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Milk production using local cattle breed-types is an age-old practice in Malawi. Although dairy farming is becoming more common as a result of the increasing population and demand for milk and milk products, there is limited knowledge of the farmers' awareness of zoonotic disease risks, their preventative practices and the disease burden in animals. This study determined dairy farmers' general knowledge of zoonoses, assessed their risks for infection with zoonotic bovine tuberculosis (bTB) and brucellosis, and evaluated farm practices to prevent disease transmission. A questionnaire was drawn up and administered by the authors. It was used to collect information about the knowledge and preventive practices of 140 out of 684 registered dairy farmers at Mzuzu Agricultural Development Division, northern Malawi. During a second visit to 60 out of the 140 farms, a total of 156 and 95 cattle were tested for brucellosis and tuberculosis, respectively. Most farmers (77.1%) knew or had heard of zoonotic diseases, whilst 75.0% correctly named at least one zoonotic disease. More survey participants named tuberculosis as a zoonotic disease compared to brucellosis (74.3% versus 2.9%). The most commonly named means of transmission were milk (67.0%) and meat (56.0%). Almost all survey participants (96.4%) practised at least one farm activity that could lead to potential transmission of brucellosis or bTB, including sale (67.0%) and consumption (34.0%) of unpasteurised milk. Antibodies against brucellosis were found in 12 cattle (7.7%), whilst one animal (1.1%) reacted to the tuberculin skin test. General knowledge about possible transmission of diseases between humans and animals was high, although most farmers practised risk behaviours that could potentially expose the public to milk-borne zoonotic diseases such as brucellosis and bTB. Furthermore, some animals had positive results for brucellosis and tuberculosis tests. Therefore, improvement of zoonotic disease prevention programmes, as well as further investigation into the prevalence and risk factors for zoonoses, is recommended.

Introduction

Dairy farming is gaining importance in Malawi. This is a result of the increasing population and demand for milk and milk products in the country's major cities. Most dairy farmers are registered and organised into about 50 milk bulking groups (MBGs) around the country's major cities: Blantyre (southern region), Lilongwe (central region) and Mzuzu (northern region) (Banda *et al.* 2011). The MBGs are mostly run and managed by farmers who collect milk from members within a radius of eight km. Following milk testing on specific gravity and alcohol testing for acidity, milk is bulked in a cooling tank. Milk is bought in bulk by the processors and a bonus is paid to the participating farmers for higher-bulk quantities. The dairy cattle breeds are predominantly Holstein-Friesians, Jerseys and their crosses with the indigenous Malawi Zebu (Banda *et al.* 2011; Tebug *et al.* 2012a). These animals are mainly stall-fed or grazed on communal pastureland near human dwellings. Although smallholder dairy farming plays a salient role in meeting the increasing demand for milk as well as milk products, and serves as an important source of employment in Malawi, these animals may also transmit diseases like brucellosis and tuberculosis to humans.

Brucellosis and tuberculosis are considered to be the most important and widespread zoonotic diseases (WHO/FAO/OIE 2004). In sub-Saharan Africa, prevalence rates of brucellosis in humans as high as 13.0% have been reported in some communities (Kunda *et al.* 2007; Schelling *et al.* 2003; Swai & Schoonman 2009). Malawi is described as non-endemic, because no case of brucellosis has been documented in humans (Pappas *et al.* 2006). However, pyrexia of unknown origin is

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not uncommon (Walsh *et al.* 2000). In contrast, tuberculosis in humans is relatively well documented and continues to be a major public health problem in Malawi (Bowie 2006; Nyirenda 2006). According to the *WHO Global TB Control Report* for 2012 there was an estimated prevalence rate of 164 per 100 000 population for tuberculosis (all forms) in the year 2011 (OIE 2012). Though no case of human tuberculosis due to *Mycobacterium bovis* (*M. bovis*) (bovine tuberculosis, bTB) has been reported in the country, isolation of *M. bovis* from milk and human tissues samples elsewhere is not uncommon (Kazwala *et al.* 1998, 2001).

In cattle, recent reports show that the prevalence rates of bTB are as high as 13.2% in the neighbouring countries of Tanzania and Zambia (Swai *et al.* 2005; Swai & Schoonman 2012). Similarly, prevalence rates of brucellosis ranging from 1.2% to 14.0% have been reported in cattle reared in different livestock systems in Tanzania and Zambia (Chimana *et al.* 2010; Karimuribo *et al.* 2007). The most recent study carried out on Malawian cattle in 1986 revealed a prevalence of 3.8% and 0.3% for bTB and brucellosis, respectively (Bedard, Martin & Chinombo 1993).

Both brucellosis and tuberculosis are considered to be occupational hazards; consumption of unpasteurised milk and physical contact with infected animals have been identified as the two most common routes for animal-to-human transmission (Fetene, Kebede & Alem 2011; Makita *et al.* 2008; Schelling *et al.* 2003). Livestock farming is believed to be an at-risk occupation, since close contact with animals is inevitable during routine farm activities (Shitaye, Tsegaye & Pavlik 2007; Swai & Schoonman 2009, 2010). Furthermore, cultural habits such as the consumption of fresh or soured milk may hamper preventive measures. Low levels of formal education may further render knowledge dissemination and control programmes to be difficult (Ayele *et al.* 2004; Shitaye *et al.* 2007). The risk of transmission of bTB and brucellosis has been reported to be influenced by livestock-keeping systems and environmental factors such as closeness to stock routes, access to surface drinking water, location of farms, age of animals and farmers' knowledge of preventive measures (Kazwala *et al.* 2001; Swai & Schoonman 2010). Disease control schemes, including compensation to farmers for infected animals that have to be culled, are not really feasible – this is mainly due to limited resources in most developing countries, including Malawi. Despite this, like in most parts of Africa, little official information about occurrence of bTB and brucellosis is available for Malawi (McDermott & Arimi 2002). Therefore, information about livestock owners' awareness, disease identification skills and preventive farm practices, which have received more recent attention, could be used to optimise disease control (John, Kazwala & Mfinanga 2008; Mosalagae, Pfukenyi & Matope 2011; Munyeme *et al.* 2010).

The present study in the northern region of Malawi was designed to determine dairy cattle farmers' general knowledge about zoonotic diseases and preventive farm practices, as well as risk of transmission from dairy cattle to farmers with regard to bTB and brucellosis.

Materials and methods

Study area, population and sampling strategy

The present study was carried out in two districts (Mzimba and Nkhata Bay) of the northern region of Malawi. Over 90.0% of the dairy cattle population in the region is found in these districts (Banda *et al.* 2012; Mzuzu Agricultural Development Division 2009). The study population comprised 684 farmers, who were organised into 12 MBGs. Each MBG had an average of 42 (range: 4–65) member farms, and each member farm had an average of 2.2 (range: 1–9) animals, including 1.2 cows per farm (Banda *et al.* 2012; Tebug *et al.* 2012a, 2012b). Mzuzu Agricultural Development Division provided a list of MBGs and dairy farmers.

The data used in this study were collected in two phases. The first phase was conducted between February 2011 and June 2011. Seven MBGs were randomly selected using a table of random numbers, from which 30.0% (140/472) of the farmers were selected and included in the survey. The second phase was carried out during the month of April 2011. One hundred and fifty-six animals from 138 farms in all 12 MBGs (146 cows and 10 bulls) and 95 cows from 74 farms were randomly selected and tested for brucellosis and bTB, respectively.

Knowledge and practices of dairy farmers with regard to zoonoses

A questionnaire was developed to assess farmers' general knowledge about zoonotic diseases, as well as preventive farm practices with regard to bTB and brucellosis. Farmers were interviewed by the same team, which was comprised of the first author (SFT) and a veterinary assistant. This questionnaire was pre-tested for clarity, and to avoid confounding questions, on a pilot group of 15 farmers; in the case of inconsistent questions, it was modified accordingly. Information contained in the first section included: (1) the location of the farm; (2) age and sex of the farm owner; (3) duration that the farmer had been dairy farming; (4) herd size; and (5) origin of the animals. In the second section, knowledge of zoonotic diseases was assessed. Farmers were asked: (1) if they knew or had heard of a disease that is naturally transmitted between animals and man; (2) to name or describe known zoonotic disease(s); and (3) to state known route(s) of transmission. In the last section, preventive measures against zoonoses (such as bTB and brucellosis) and milk-handling practices were assessed. In this section, farmers were asked: (1) if they or any family member had ever undergone medical examination for zoonotic diseases; (2) if their animals had ever been tested by a veterinarian for any zoonotic diseases; (3) whether or not milk was processed or boiled before consumption; and (4) where the milk was sold.

Brucella antibody and tuberculin skin test

Blood samples (about 7.5 mL) were collected from the jugular vein of the cattle. After coagulation and centrifugation (1500 x 15 min) serum was extracted and stored at 2 °C – 4 °C for 3–21 days until analysis was carried out. A competitive

Enzyme Linked Immunosorbent Assay kit (Brucella-Ab C-ELISA, Svanova Biotech AB, Uppsala, Sweden) was used for serological analysis (Centre Veterinary Laboratory, Lilongwe, Malawi). This test distinguishes between *Brucella* infected animals, *Brucella* strain 19 vaccinated animals and animals infected with cross-reacting gram-negative bacteria. Samples were tested in singles following the manufacturer's recommendations (Svanova Biotech AB) as described elsewhere (Bayemi *et al*. 2009).

For intradermal tests for bTB, bovine and avian purified protein derivatives (PPD) (supplied by ID-Lelystad, Netherlands, and Veterinary Laboratories Agency, Weybridge, UK, respectively) were used. Intradermal injections of 0.1 mL of bovine PPD and avian PPD were administered on shaved sites of the mid-neck region. The injection sites were examined 72 ± 6 h later and any swelling was measured with a pair of callipers. Interpretation of the results was based on the World Organisation for Animal health (OIE) recommendations (OIE 2009). Briefly, animals with a difference in skin thicknesses after bovine tuberculin and avian tuberculin injections in the subcutaneous immunotherapy test (SCIT) (by subtracting the increase in avian site from the increase in the bovine site) of > 4 mm, > 2 mm but < 4 mm and < 2 mm were considered positive, inconclusive and negative, respectively (OIE 2009).

Statistical Analysis

The data obtained were entered in Microsoft Excel® (Microsoft, USA) and transferred to Minitab® 16 Statistical Software (Minitab, Inc., State College, Pennsylvania, USA). Descriptive statistics were generated and the association between different variables (dairy farmer and farm characteristics) and knowledge or farm practices with regard to zoonoses were assessed by chi-square (χ^2) test. Odds ratios (OR) and confidence intervals (CI) were calculated to assess potential risk indicators associated with brucellosis seroprevalence in a univariate logistic regression model. Potential risk indicators included in the models were identified based on previously reported risk factors (Shitaye *et al*. 2007; Swai & Schoonman 2009, 2010) and on availability of data, under practical conditions in Malawi, such as area, grazing system, origin of cows, breeding practice and age of animals. Unadjusted risk indicators associated with brucellosis in this study in the univariate model ($p \leq 0.25$) were included in a multivariate logistic model. The age of animals and duration in dairy farming were grouped into two categories each (above respective median value, below respective median value). For all χ^2 tests, as well as for logistic univariate and multivariate models, p-values < 0.05 were considered to be significant.

Results

Knowledge and practices of dairy farmers with regard to zoonoses

One hundred and eight (108/140) (77.1%) survey participants had heard or believed that there are diseases that are naturally transmitted between animals and man, 14.0% (20/140) were not sure, whilst 9.0% (12/140) were certain that they had never heard of such diseases (Table 1). Three-quarters (105/140) of the survey participants correctly named at least one zoonotic disease. About two-thirds (95/140) of all the survey participants correctly named one route of zoonotic disease transmission. Bovine tuberculosis was the most commonly named zoonotic disease and milk was the most frequently mentioned potential means of zoonotic disease transmission. Sale of unpasteurised milk was known by most of the farmers to be a potential risk factor for disease transmission.

All survey participants consumed home-produced milk. Almost all survey participants (96.0%) practised at least one activity that could lead to milk-borne transmission of bTB or brucellosis, such as no or irregular testing of animals for

TABLE 1: Named zoonotic diseases, possible means of transmission and preventative measures in smallholder dairy farms

Variable	Category	Number of survey participants	%
Named zoonotic diseases	Bovine tuberculosis	104	74.3
	Rabies	21	15.0
	Brucellosis	4	2.9
	Bird flu	4	2.9
	Others†	8	5.7
	Mean number of named zoonoses per farmer (± SEM)	1.0 ± 3.6	-
Mode of transmission	Contaminated milk	94	67.1
	Contaminated meat	79	56.4
	Aerosol	33	23.6
	Contact with infected animals	11	7.9
Preventive measures	Medical check-up‡	22	15.7
	Veterinary check§	26	18.6
Milk usage	Sale to the MBG and public	71	50.7
	Sale to MBG only	70	49.3
Consume only boiled milk at home	Yes	92	65.7
	No	48	34.3

†, Worms, mastitis, name not known.
‡, Farmer had gone for tuberculosis test previously.
§, Herd had been checked at least once for zoonotic disease(s).
n = 140

those diseases (26/140), as well as consumption (48/140) or sale (71/140) of unpasteurised milk (Table 2). A significantly higher proportion ($p < 0.05$) of farmers from Nkhata Bay district (51.1%) consumed unpasteurised milk compared to those in Mzimba district (25.0%). A higher percentage of women (57.1%) compared to men (37.5%) ($p < 0.02$) named at least one mode of transmission of zoonotic diseases.

Brucella antibody and tuberculin skin test

Of the 156 animals tested, 12 (7.7%) had antibodies against *Brucella* species. In the univariate logistic regression models, a higher age and free or partial grazing were associated with occurrence of antibodies against brucellosis ($p < 0.05$) (Table 3). In the final multivariate logistic regression model, only animals older than or equal to five years were more likely (OR = 6.97; 95.0% CI = 1.41–34.36) to have experienced a *Brucella* infection than those younger than five years. One out of 95 (1.1%) cattle was positive for bTB.

Discussion

Knowledge of zoonoses amongst dairy farmers was high; more farmers reported bTB (74.3%) as a zoonotic disease than brucellosis (15.0%). A similar observation was made in a study of animal handlers in Cameroon, where 68.0% knew bTB as zoonotic (Awah Ndukum *et al.* 2010). The percentage of farmers who named bTB as a zoonotic disease was higher than the 39.6% and 16.1% of cattle owners and smallholder dairy farmers in Zambia and Zimbabwe, respectively (Mosalagae *et al.* 2011; Munyeme *et al.* 2010). In contrast to both of these other studies, in which the majority (88.0% and 74.8%, respectively) of the survey participants were male, most (60.0%) of the survey participants in the current study were women. Significantly, in the present study, more women than men named one mode of transmission ($p < 0.05$) and knew of milk-borne diseases ($p = 0.05$), which may explain the overall high-level of awareness observed. The relatively high level of awareness of bTB may also be due to

TABLE 2: Association of some smallholder dairy farmer characteristics, milk-borne disease awareness and milk consumption habits.

Variable	Category	*n*	Number of survey participants					
			Aware of at least one milk-borne disease	%	Know at least one mode of transmission	%	Sometimes drink fresh or cultured† milk	%
Location	Nkhata Bay district	45	37	82.20	35	77.80	23	51.10
	Mzimba district	95	69	72.60	69	72.60	25	26.30
	χ2 (*p*-value)	-	1.53	0.21	0.42	0.52	8.33	0.00
Gender	Male	56	22	39.30	21	37.50	20	35.70
	Female	84	47	56.00	48	57.10	28	33.30
	χ2 (*p*-value)	-	3.73	0.05	5.18	0.02	0.08	0.77
Education	Below primary education	100	50	50.00	50	50.00	34	34.00
	Above primary education	40	19	47.50	19	47.50	14	35.00
	χ2 (*p*-value)	-	0.07	0.79	0.07	0.79	0.08	0.77
History of TB in the family	Previous history of TB	10	7	70.00	7	70.00	4	40.00
	No previous history of TB	130	62	47.70	62	47.70	44	33.80
	χ2 (*p*-value)	-	1.85	0.17	1.85	0.17	0.16	0.69
Duration in dairy farming	Below 5 years	60	33	55.00	33	55.00	18	30.00
	Above 5 years	80	36	45.00	36	45.00	30	37.50
	χ2 (*p*-value)	-	1.37	0.24	1.37	0.24	0.86	0.35
Source of animals	Personal resources only	57	32	56.10	31	54.40	20	35.10
	Personal resources and donors	82	37	45.10	38	46.30	28	34.10
	χ2 (*p*-value)	-	1.63	0.20	0.87	0.35	0.01	0.91

†, non-pasteurised fermented milk.

TABLE 3: Animal-level univariate logistic analysis of risk factors associated with brucellosis seroprevalence.

Factor	Category	Numbers examined	Positive reactors	Positive reactors in %	OR	CI (95.0%)	*p*-value
District	Mzimba	124	10	8.1	1.33	0.27 – 6.38	0.731
	Nkhata Bay	32	2	6.3	-	-	-
Origin of cows	Imported	46	4	8.7	1.20	0.34 – 4.21	0.773
	Locally bred	110	8	7.3	-	-	-
Grazing system	Zero	134	8	6.0	4.07	1.09 – 15.14	0.036
	Free or partial	22	4	18.2	-	-	-
Breeding practice	AI only	17	2	11.8	2.00	0.40 – 10.12	0.402
	Natural and AI	139	10	7.2	-	-	-
Age (years)	< 5	93	2	2.1	8.58	1.81 – 40.67	0.007
	≥ 5	63	10	15.9	-	-	-
History of retained placenta and/or abortions†	Yes	23	3	13.0	1.86	0.46 – 7.43	0.382
	No	126	9	7.1	-	-	-
Lactation number	< 2	120	8	6.7	1.50	0.79 – 2.84	0.210
	≥ 2	29	4	13.8	-	-	-

OR, Odds ratio; CI, Confidence interval; AI, Artificial insemination
†, only female animals were considered
n = 147

tuberculosis in humans, which is closely associated to HIV and AIDS; this is a leading cause of death (estimated at 35.8% of all deaths) in Malawi (Bowie 2006; Nyirenda 2006).

Unlike tuberculosis, it was found that little is known about brucellosis, which does not reflect the apparent disease burden in animals. Poor knowledge of brucellosis is thought to significantly impede people who are infected with brucellosis from seeking medical services; this is thought to have contributed to under-diagnosis and under-reporting of zoonoses in neighbouring Tanzania (John *et al.* 2008; Kunda *et al.* 2007). Given the relatively high number of cattle with antibodies against brucellosis, low level of awareness, low formal education, as well as the unpasteurised milk-consumption habit observed in the present study, this is likely to be the case in northern Malawi (Table 2). Unpasteurised milk is either consumed as fresh milk or as fermented curdled sour milk (*chambiko*). Higher risk of infection with bTB and brucellosis has been found to be associated with non-heated milk consumption (Fetene *et al.* 2011; Kochar *et al.* 2007; Makita *et al.* 2008). Fermentation of unpasteurised milk to pH values below pH 4.0 has been shown to not inhibit the growth of *Brucella* strains (Zuniga Estrada *et al.* 2005).

This investigation demonstrated that animals are not checked for zoonotic diseases on a regular basis. Few farms (19.0%) reported that a veterinarian had tested their animals at least once for a zoonotic disease (mainly tuberculosis) due to cost reasons and lack of knowledge. As previously noted (McDermott & Arimi 2002), information on zoonotic disease burden in most African countries remains scarce. Although the prevalence recorded in this study (1.1%) may not be a true reflection of the real situation (because of the small sample size used), reaction to the tuberculin skin test and the presence of antibodies against *Brucella* infection in dairy cattle demonstrate that these diseases occur in the area. This is also not surprising given that both diseases had been reported previously in Malawian cattle (Bedard *et al.* 1993). In addition, about 76.0% of the dairy cattle population in the study area are of exotic breeds (Tebug *et al.* 2012a), most of which were imported from countries like Zambia and South Africa where brucellosis has also been reported in cattle (Chimana *et al.* 2010; Hesterberg *et al.* 2008; Swai & Schoonman 2010). Brucellosis has a wide clinical spectrum in humans (Kochar *et al.* 2007) and symptoms might be misdiagnosed for other febrile diseases such as malaria. The results of this study indicate that zoonotic diseases could be transmitted from dairy cattle to humans. Therefore, further investigations, as well as concerted veterinary and medical efforts in the control of zoonotic diseases in Malawi, would be beneficial.

Conclusion

Evidence of both bTB and brucellosis was present in cattle on smallholder dairy farms in northern Malawi. Most dairy farmers knew bTB to be a zoonotic disease, yet farm practices that constitute a high potential public health risk, such as consumption of unpasteurised milk, were still common. Despite the relatively high number of cattle with antibodies against brucellosis, little was known about this zoonotic disease. Seroprevalence of brucellosis was higher in cows older than five years. Therefore, efforts by both veterinary and medical personnel should focus on effective ways of improving: farmers' knowledge of zoonotic bTB and brucellosis transmission, the development of improved herd disease management plans, and the establishment of food safety systems.

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Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

S.F.T. (University of Kiel; International Livestock Research Institute, Kenya) performed most of the experiments, including the planning of the study and the analyses of data, as a PhD-student. M.G.G.C. (Scotland's Rural College) and J.A. (University of Plymouth) made contributions in study conception, data analysis and interpretation. G.R.N. (Central Veterinary Laboratory Lilongwe) and J.P.M. (World University Service of Canada) participated in data acquisition and laboratory analyses. S.W. (University of Kiel) made contributions to statistical analyses and interpretation as well as to drafting of manuscript.

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